

1 **NON-WOVEN FABRIC**

2

3 This invention relates to a non-woven fabric and its
4 uses, and relates more particularly but not exclusively
5 to the use of a needlefelt for the covering of tennis
6 balls, and to tennis balls so covered.

7

8 For the meaning of textile-related terms as used in
9 this specification, attention is directed to the
10 definitions in the reference book "Textile Terms And
11 Definitions" (Eighth Edition) published in 1986 by The
12 Textile Institute (of the United Kingdom). References
13 in this specification to "tennis ball(s)" are to be
14 taken as comprising references to analogous balls, i.e.
15 to balls for games other than tennis but which are
16 resilient hollow balls or otherwise structurally and
17 functionally analogous to tennis balls, whether or not
18 such analogous balls are interchangeable with tennis
19 balls, and to felt-covered balls in general.

20

21 Traditionally, tennis balls have been covered with a
22 felted textile material having a surface predominantly
23 composed of wool fibres and based on a woven scrim or
24 substrate. During the process of finishing the felted
25 textile material, the scale structure of the wool

1 fibres is utilised to produce the characteristic felted
2 surface appearance of the ball.

3
4 Nowadays woven felts for covering tennis balls are
5 produced with a surface that is commonly composed of a
6 mixture of wool and polyamide fibres. Usually these
7 fibres are mixed at a ratio of about 60% wool & 40%
8 nylon, but this ratio may vary in dependence on the
9 wear characteristic required of the ball. It is also
10 desirable that the back side of the felt (which is the
11 side of the felt intended to be adhered to the core of
12 the ball) be made of a material which provides a good
13 adhesion when it is glued onto the hollow rubber sphere
14 forming the core of the ball. Usually such backing is
15 made of cotton.

16
17 Following the introduction of needlefelting machines,
18 attempts have been made to produce and utilise
19 needlefelts (felts composed of non-woven fabrics and
20 produced by needlefelting machines) for covering tennis
21 balls. Needlefelting techniques can be used to produce
22 a non-woven fabric for covering tennis balls in
23 accordance with the following method :- an appropriate
24 blend of fibres, either dyed or undyed, is carded and
25 cross-lapped to form a substantially horizontal fibre
26 batt (a non-woven web). The fibres of the batt are
27 provided in a generally planar configuration and are
28 superimposed according to successive horizontal
29 patterns. This batt is then passed through a known
30 form of needlefelting machine. Such a needlefelting
31 machine has at least one reciprocable panel (or
32 "needleboard") comprising a cluster or array of barbed
33 needles arranged mutually parallel, pointing in the
34 same direction, and secured on a common substrate or
35 mounting. The needlefelting machine may have two
36 independently operable needleboards arranged on

1 mutually opposite sides of the fibre web and disposed
2 in succession along the normally horizontal path
3 followed by the batt as it passes through the machine
4 during needlefelting operation. As the batt is passed
5 horizontally through the needlefelting machine, the or
6 each needleboard is vertically reciprocated to cause
7 its cluster of barbed needles repeatedly to punch into
8 and through the web, and then back out of the fabric
9 web (on the same side as entry). The vertical passage
10 of the barbed needles back and forth through the batt
11 provokes a vertical entanglement of the fibres in the
12 batt as the barbs of the needles carry some portion of
13 the fibres along their pathways through the batt.

14
15 Needlefelting machines have a higher productivity of
16 fabric than looms producing woven fabric, and
17 needlefelting machines will produce a felted fabric
18 without the need to incorporate costly wool fibres and
19 without the need to apply expensive finishing processes
20 to the fabric. Consequently ball-covering needlefelts
21 are cheaper than ball-covering woven fabrics. However,
22 needlefelts lack the flexibility that is characteristic
23 of woven fabrics, and consequently when balls are
24 covered with shaped blanks of needlefelt, the seams of
25 the covering are liable to be defective due to
26 puckering of the blanks. Also, the so-covered balls
27 tend to feel hard when hit, exhibit poor flight
28 characteristics, and have poor wear resistance. These
29 adverse properties arise from the smoother surface and
30 greater consolidation of non-woven felts in comparison
31 to woven felts.

32
33 Attempts have been made to overcome the above-discussed
34 defects of conventional needlefelted ball coverings,
35 for example by modifying needling density (needle
36 penetrations per unit area of web), or by incorporating

1 a felt-backing scrim of greater flexibility; such
2 attempts have not been successful. In a recent attempt
3 to increase fibre entanglement in the finished felt, a
4 percentage of wool fibre has been incorporated into the
5 fibre blend prior to needlefelting, and the
6 needlefelted fabric has been milled in a manner similar
7 to the milling of woven felts. However, the non-woven
8 fabrics that resulted from these procedures still
9 failed to replicate the desirable characteristics of
10 good-quality woven ball-covering felts.

11

12 A comparative study of the cross-sectional
13 characteristics or microstructure of traditionally
14 woven tennis ball felts and non-woven felts produced by
15 needlefelting machines showed that fibres in woven felt
16 are predominantly anchored in the base woven structure
17 but are distributed in generally random directions
18 throughout the surface pad of the felt, thus producing
19 a high level of fibre intersections for a given density
20 of felt. Also, the fibre density declines from the
21 scrim (basecloth or backing) of the felt towards the
22 opposite surface (normally the outer surface). The
23 base structure retains a woven characteristic, and has
24 a significantly greater fibre density than the outer
25 surface. A typical woven ball-covering felt has a
26 fibre density of 300 milligrams per millilitre at its
27 base, diminishing to about 150 milligrams per
28 millilitre towards the opposite (outer) surface. These
29 characteristics, particularly the degree of fibre
30 entanglement per unit density, are critical to the
31 behaviour of the felt both during the ball-covering
32 process and on the ball in play (i.e. in use).
33 Conventional needlefelting techniques redistribute a
34 proportion of the fibres laid predominantly
35 horizontally during the cross-lapping process into a
36 predominantly vertical configuration, the fibres

1 needed to verticality intersecting those not impacted
2 by the needles at or close to right angles. Also, the
3 fibre density (excluding any scrim material) can be
4 seen to be nearly consistent throughout the thickness
5 of the felt. From these observations it becomes
6 apparent that the ratio of fibre intersections or
7 degree of fibre entanglement is much lower in
8 needlefelt than in woven felt for a given density of
9 material. Thus, in order to achieve acceptable
10 abrasion resistance and wear resistance characteristics
11 in a ball that is covered in a needlefelt by means of
12 giving the needlefelt a level of fibre entanglement
13 that is comparable to that in a woven ball-covering
14 felt, it is necessary to apply a high needling density
15 (number of needle penetrations per unit of web area).
16 High needling density renders the resultant needlefelt
17 significantly less flexible than woven ball-covering
18 felt, thus making the ball-covering process more
19 difficult and more prone to defects. Balls covered
20 with highly needled felt feel harder when hit than
21 balls covered in woven felt, and generally fly faster
22 due to the needlefelt surface being smoother and more
23 consolidated than the surface of a woven felt. Such
24 deficiencies may not be particularly significant for
25 recreational use of tennis balls, but the defects in
26 ball characteristics renders such balls unacceptable
27 for use in professional tennis and in championship-
28 level tennis matches.

29
30 From the facts detailed above, it can be concluded that
31 felted ball coverings produced using conventional
32 nedlefelting techniques cannot replicate the density
33 and wear characteristics equivalent to woven ball-
34 covering felts and simultaneously provide the
35 performance characteristics required of good-quality
36 tennis balls (e.g tennis balls of championship

1 standard).

2

3 It has now been discovered that a needlefelt produced
4 by a needlefelting machine having a needleboard which
5 is curved or otherwise shaped to ensure fibre
6 entanglement in a range of angles (transverse to the
7 plane of the felt web) exhibits surprisingly good
8 characteristics of both wear and covering capabilities,
9 and is particularly suitable for tennis ball coverings.

10

11 Such needlefelting machines are available from the
12 Austrian Company Textiles Maschinenfabrik Dr E. Ferher
13 AG and are known in the Trade as machines incorporating
14 "Ferhrer H1 Technology" (see published British Patent
15 Applications GB2306519-A, GB2310221-A, GB2312220-A,
16 GB2315281-A, & GB2316957-A). However, these novel
17 needle felting machines and techniques have never
18 previously been proposed for production of a non-woven
19 fabric having characteristics suitable to be used as a
20 tennis ball covering.

21

22 According to a first aspect of the present invention
23 there is provided a method of forming a felt covering
24 for a ball, characterised by the steps of forming a
25 needlefelt comprising an entanglement of fibres
26 produced by needling a fibre batt in a range of angles
27 including a plurality of angles which are non-
28 perpendicular to the plane of the batt, and cutting or
29 otherwise shaping the needlefelt to form a blank
30 adapted at least partially to cover a ball.

31

32 The batt is preferably curved during needling, and
33 where the batt is moved longitudinally as a step in the
34 needling process, the batt is preferably curved in a
35 longitudinal direction while being needled.

36

1 According to second aspect of the present invention
2 there is provided a needlefelt for a ball covering,
3 said needlefelt being characterised in that it
4 comprises an entanglement of fibres formed by the
5 needlefelting of a fibre batt passed through a
6 needlefelting machine having at least one needleboard
7 providing barbed needles to penetrate said web in a
8 range of angles including a plurality of angles which
9 are non-perpendicular with respect to the plane of the
10 batt, and in that said needlefelt is cut or otherwise
11 shaped to form a blank adapted at least partially to
12 cover a ball.

13
14 During needling of the batt in the needlefelting
15 machine the batt is preferably curved in the direction
16 of its travel through the needlefelting machine, and
17 the needleboard is preferably correspondingly curved.
18 The needlefelting machine preferably comprises two
19 needleboards at respective locations which are mutually
20 displaced along the direction of travel of the batt
21 through the needlefelting machine and which are
22 preferably disposed to needle the batt from mutually
23 opposite sides of the batt. Where the needlefelt
24 incorporates a scrim, the first of said two
25 needleboards is preferably disposed to needle the
26 layered combination of batt and scrim from the side
27 opposite to the scrim.

28
29 Prior to needled, the batt may be subjected to a
30 preliminary consolidation and fibre entanglement in a
31 pre-needling machine, the batt preferably being curved
32 in its direction of travel through the pre-needling
33 machine.

34
35 The ball is preferably a resilient hollow ball, and may
36 be a tennis ball.

1 According to a third aspect of the present invention
2 there is provided a felt-covered ball, characterised in
3 that the ball-covering felt is a needlefelt comprising
4 an entanglement of fibres formed by the needlefelting
5 of a fibre batt passed through a needlefelting machine
6 having at least one needleboard providing barbed
7 needles to penetrate said web in a range of angles
8 including a plurality of angles which are non-
9 perpendicular with respect to the plane of the batt.

10

11 Said felt-covered ball preferably comprises a hollow
12 resilient core to which the needlefelt covering is
13 adhered, and said ball may be a tennis ball.

14

15 According to a fourth aspect of the present invention
16 there is provided a felt-covered ball, characterised in
17 that the ball is covered with needlefelt produced by
18 the method according to the first aspect of the present
19 invention.

20

21 According to fifth aspect of the present invention
22 there is provided a felt-covered ball, characterised in
23 that the ball is covered with needlefelt according to
24 the second aspect of the present invention.

25

26 The ball according to the fourth or fifth aspects of
27 the present invention may be a tennis ball.

28

29 Embodiments of the invention will now be described by
30 way of example with reference to the accompanying
31 drawings wherein :

32

33 Fig. 1 is a schematic representation of the needle
34 paths followed by the needles in conventional
35 needling in a conventional needlefelt;

36

1 Fig. 2 is a schematic representation of the needle
2 paths following by the needle in the needlefelt
3 applied to ball covering in accordance with the
4 present invention; and

5
6 Fig. 3 is a schematic representation of a
7 needlefelting machine and process for the
8 production of a ball-covering needlefelt in
9 accordance with the present invention.

10
11 Fig. 4 is a schematic representation of fibre
12 entanglement in a conventional needlefelt.

13
14 Fig. 5 is a schematic representation of fibre
15 entanglement in the needlefelt applied to ball
16 covering in accordance with the present invention.

17
18 Referring first to Fig. 4, this is a schematic cross-
19 section through a conventional needlefelt 9, the cross-
20 section being taken in a vertical longitudinal plane.
21 The needlefelt 9 is formed from a web or batt of non-
22 woven fibres, the batt being of indefinite length from
23 left to right as viewed in Fig. 4 (which depicts a
24 short piece of the batt). The vertical lines shown in
25 Fig. 1 (19) depict the needle paths followed by the
26 needles during the conventional needlefelting process
27 which provoke change of orientation of some of the
28 fibres from initially horizontal alignments to vertical
29 alignment (i.e. at right angles to the plane of the
30 batt). It is to be particularly noted that the fibres
31 in this conventional needlefelt 9 are entangled to a
32 minimal extent.

33
34 Referring now to Fig. 2, this schematically depicts the
35 needlepaths 28 of needles used to produce a needlefelt
36 18 as shown in Fig. 4 with highly entangled fibres.

1 Such needlepaths are produced by the needlefelting
2 machinery about to be described with reference to Fig.
3 3. To produce the needlefelt 18 of Fig. 5, an
4 appropriate blend of fibres, either dyed or undyed, is
5 carded and cross-lapped to form a fibre batt 10 (Fig.
6 3) as a starting material for the needlefelting
7 processes to follow. The batt 10 weighs between 350
8 grams per square metre and 850 grams per square metre
9 depending on the weight required for the finished
10 product. The fibres of the batt 10 could be composed of
11 a mixture of wool and polyamide fibres, but other
12 fibres could be incorporated or substituted as
13 necessary or desirable.

14
15 The batt 10 is then passed through a pre-needling
16 needlefelting machine 11 wherein the batt is curved
17 while being needled such that the needles penetrate the
18 batt in a range of angles, including a plurality of
19 angles which are non-perpendicular to the surface of
20 the batt. The machine 11 has a correspondingly curved
21 needleboard 12 containing about 5000 needles disposed
22 in a down-punch configuration (i.e. the needles are
23 driven into the batt from above). The pre-needling
24 machine 11 is advantageously of the type described in
25 GB2315281-A, and as sold under the Trade Name "Fehrer
26 H1 Technology" by the Fehrer Company of Austria.

27
28 The shape and size of the needles selected for use in
29 the pre-needling machine 11 would depend on the results
30 required. These needles are preferably three-inch, 40-
31 gauge needles with regular barbs. Draft (reduction of
32 linear density by drawing or longitudinal stretching),
33 needle penetration depth and penetration density
34 (number of needle penetrations per unit area of batt)
35 are varied according to product requirements. For a
36 tennis ball covering of good quality it is preferred to

1 use a draft of about 15% and to provide a penetration
2 depth of about 10 millimetres at about 80 needle
3 penetrations per square centimetre of batt.
4

5 The pre-needled batt of fibres 13 as delivered from the
6 pre-needling machine 11, together with an appropriate
7 scrim (backing fabric) 14, are passed through a finish
8 needling machine 15 with the width and length of the
9 batt 13 being generally horizontal. The scrim 14 is
10 preferably a polyester or polyamide warp knit with a
11 weight of about 75 grammes per square metre. The
12 machine 15 has two needleboards 16 & 17, each
13 needleboard of the needleboards 16 & 17 containing
14 approximately 5000 needles, the first needleboard 16
15 being disposed in up-punch configuration and the second
16 needleboard 17 being disposed in down-punch
17 configuration. ("Up-punch" refers to the needles being
18 driven into the batt from below, and "down-punch"
19 refers to the needles being driven into the batt from
20 above). Each of the needleboards 16 & 17 is curved in
21 a longitudinal plane, i.e. a plane which extends in the
22 direction of batt travel through the needling machine
23 15 and which is also vertical to the lateral extent of
24 the generally horizontal batt 13 (e.g. as described in
25 GB2306519-A & GB2312220-A), the batt 13 (and scrim 14)
26 being correspondingly curved during needling by the
27 respective needleboards 16 & 17. Such curvature
28 results in the batt 13 and scrim 14 being needled in a
29 range of angles, including a plurality of angles which
30 are non-vertical to the surface of the batt, thereby to
31 produce a needlefelt in which the fibres are highly
32 entangled (as depicted in Fig. 2).
33

34 At the upstream or input end of the needling machine
35 15, the scrim 14 is in-fed to lie along and above the
36 fibre batt 13. Thus the first (up-punch) needleboard

1 16 of the finish needling machine 15 will needle fibres
2 from the fibre batt 13 upwardly through the scrim 14
3 while the second (down-punch) needleboard 17 will
4 needle fibres back down through the scrim 14 into the
5 fibre batt 13. By selectively altering the punch
6 density and the depth of needle penetration by the
7 second needleboard 17 it is possible to controllably
8 alter the fibre density through the thickness of the
9 finished needlefelt 18.

10

11 The needles selected for use in the finish needling
12 machine 15 would depend on the results required. These
13 needles are preferably 3-inch, 40-gauge needles with
14 regular barbs. Draft, needle penetration depth and
15 penetration density can be varied according to product
16 requirements; by suitably varying these parameters it
17 is possible to alter the flexing characteristics,
18 surface appearance and wear characteristics of the
19 product. For tennis ball coverings of a good quality
20 it has been found that a penetration of 14 millimetres
21 at down-punch and a penetration of 10 millimetres at
22 up-punch with a punch density of 80 penetrations per
23 square centimetre without drafting (i.e. without
24 reducing linear density by drawing or longitudinal
25 stretching) can produce good results with regard to
26 meeting the performance characteristics required for
27 championship tennis. Reference to Fig. 2 will show the
28 reason for this improvement in properties, namely the
29 entanglement of fibres at various different angles due
30 to the several different needle penetration angles
31 arising from the imposition of longitudinal curvature
32 on the batt as it is needled (see Fig. 6 of GB2310221-
33 A, & Fig. 1 of GB2312220-A).

34

35 The needlefelt tennis ball covering material so
36 produced may optionally be subjected to further

1 processing. For example, a woollen milling process
2 can, if required, be used to enhance the felt
3 characteristics, particularly in respect of appearance
4 and some aspects of wear. Additionally, the needlefelt
5 may be dyed at this stage and dried. A shearing or
6 cropping process may also be deemed appropriate.

7
8 The needling process carried out on longitudinally
9 curved batt produces fibre entanglement by moving
10 fibres through the thickness of the felt at angles
11 other than the conventional 90 degrees to the felt
12 surface thus giving increased fibre to fibre contact at
13 lower punching densities. This allows the manufacture
14 of a needlefelt having high levels of fibre
15 entanglement but without excessive consolidation. By
16 using such needlefelting technology and controlling the
17 depth of needle penetration it is possible to vary and
18 control the density of the felt through its thickness.

19
20 To make a tennis ball covered by the needlefelt
21 obtained by the process described with reference to
22 Fig. 3, suitably shaped blanks are cut from the
23 needlefelt, and then glued on to a ball core
24 constituted by a resilient hollow rubber sphere of
25 appropriate dimensions. Such blanks may be the
26 "figure-eight" blanks traditionally used in pairs for
27 forming the covering of a tennis ball. The scrim 14
28 provides a smooth backing surface enabling good
29 adhesion between the needlefelt and the hollow rubber
30 core of the ball.

31
32 The preferred needling machinery for producing ball-
33 covering felts is schematically depicted in Fig. 3, but
34 modified arrangements may be utilised. For example,
35 two separate needling machines (not shown) may be
36 utilised in tandem (with suitable synchronisation of

1 batt movement). Alternatively, a needling machine with
2 only a single needleboard may be utilised. The pre-
3 needling machine may be integrated with the needling
4 machine, or omitted from the needlefelting process.

5
6 While certain modifications and variations of the
7 preferred embodiments have been described above, the
8 invention is not restricted thereto, and other
9 modifications and variations can be adopted without
10 departing from the scope of the invention as defined in
11 the appended claims.

12
13